Should Electric Vehicle Purchase Subsidies be Linked with Scrappage Requirements?

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Should electric vehicle purchase subsidies be linked with scrappage requirements?*

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Abstract

We build a vehicle purchase and disposal model that accounts for trade-in opportunity costs to analyze a program that links an electric vehicle (EV) purchase subsidy with a gasoline vehicle scrappage requirement. We evaluate the program based on changes in sales and scrappage, subsidy dollars spent, and the degree of additionality, or the extent to which households make decisions beyond business-as-usual behavior. We measure two distinct forms of additionality—one involving the vehicle purchase decision, denoted as “purchase additionality,” and one for the scrap decision, denoted as “scrappage additionality.” We find that linking a purchase subsidy with a scrappage requirement is expected to result in fewer EV sales and less spending relative to a program without linking. While linking lowers purchase additionality relative to a program without a scrappage requirement, it leads to a high degree of scrappage additionality. Our results highlight the importance of accounting for opportunity costs when evaluating subsidy policies.

JEL codes: D12, H23, L62, Q41

Key words: electric vehicles, purchase subsidies, opportunity costs, linking

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# Introduction

While electric vehicles (EVs) have grown in popularity among new vehicle buyers in the last few years, they still represent only about 1 percent of all passenger vehicles on the road in the United States. This statistic is driven by two features of the passenger vehicle market: the national new vehicle market share for EVs remains well under 10 percent, and the on-road stock of vehicles takes decades to be replaced by new vehicle stock.

To accelerate the transition of the passenger vehicle to EVs, US senator Chuck Schumer proposed a Clean Cars for America plan in 2019, which outlined a policy that would link an EV purchase subsidy with a vehicle scrappage requirement. Specifically, the policy would provide a point of sale rebate that can be redeemed toward purchasing an EV. To obtain the rebate, buyers would need to trade in a gasoline-powered vehicle in driving condition to a dealer or registered business. The dealer or registered business would then have the vehicle scrapped. Although to date the proposal has not been presented in bill form to Congress, features of the program could be incorporated in future bills.

Conceptually, this type of policy represents linking a vehicle scrappage requirement with a standard purchase subsidy. Historically, the United States has adopted both linked and unlinked purchase subsidies for increasing sales of fuel-efficient and alternative fuel vehicles. Key examples of unlinked subsidies include prior federal tax credits for hybrid vehicles and current federal tax credits for EVs. The most notable example of a linked subsidy was the Car Allowance Rebate Program, hereafter denoted as the Cash for Clunkers program, which provided a purchase subsidy for a high fuel economy vehicle conditional on the buyer providing a low fuel economy used vehicle to be scrapped under the program.

We empirically evaluate the proposed Schumer plan that would link a vehicle scrappage requirement with a purchase subsidy using detailed new vehicle purchase and trade-in data from 2018 and a model of purchase decisions and vehicle scrappage. We compare outcomes of the policy with a standard unlinked purchase subsidy, including sales and spending impacts. We also evaluate the policy based on additionality. Ideally, all subsidy payments would go to households that would require financial compensation to change their behavior. But this ideal rarely occurs in practice, since households have private information about their vehicle purchase preferences. Without the ability to perfectly screen households, subsidy policies will invariably provide financial benefits for actions that

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1 A summary of the proposal can be found here.
2 The proposed plan included subsidies for EVs, plug-in hybrid electric vehicles, and hydrogen fuel cell vehicles. In this paper we will use “EVs,” “clean cars,” and “clean vehicles” interchangeably when discussing vehicles that may be purchased as part of the program.
3 Recent examples of bills that include subsidies for electric vehicle purchases include the Biden administration’s Build Back Better Act and the Inflation Reduction Act.
would have happened anyway, or non-additional behavior. Non-additional payments are considered financially wasteful and represent windfalls to those receiving them.

Our data and modeling allow us to evaluate the policy using two distinct forms of additionality. We quantify “purchase additionality,” which we define as the degree to which new EV purchases are additional to baseline buying decisions. We also quantify “scrappage additionality,” which we define as the degree to which used gasoline vehicle scrappage decisions would not have occurred without the subsidy.

Our analysis yields five key results. First, we find that linking a scrappage requirement with a purchase subsidy significantly lowers the sales effect of the policy. We find that the eligibility requirements and financial opportunity costs inherent in linking drastically reduce the number of buyers that would be willing and able to participate in the program. From an eligibility standpoint, linking restricts the type of households that could participate, since only a fraction of households own vehicles that would make them eligible to participate. Furthermore, among eligible households, we find that many would not participate because the value of their trade-in vehicles exceeds the value of the subsidy.

Second, for the same amount of subsidy payment, linking lowers the degree of purchase additionality. The mechanics of this result involve quantifying the opportunity cost that buyers face when considering participating in the program. Buyer opportunity costs are defined by the trade-in or scrap value of the gasoline vehicles that they could use to opt in to the program. If they do not opt in, they receive the trade-in or scrap value of their used gasoline vehicle when they make a new vehicle purchase. This opportunity cost effectively lowers the financial value of the purchase subsidy. As a consequence, we find the effective subsidy that takes into account the opportunity cost of the trade-in vehicle for the linked program to be about half as large as a standard subsidy payment without a vehicle scrappage requirement. The lower effective subsidy implies a lower degree of additionality, since fewer buyers are provided with sufficient financial incentive to change their purchase behavior.

Third, we find that linking leads to a large majority of additional vehicle scrappage decisions or a high degree of scrappage additionality. Among respondents in our sample that reported disposing of a vehicle, most reported trading in their used gasoline vehicles for credit toward their new vehicle purchase, and only a small fraction reported scrapping their disposed vehicles. In fact, our data suggest that about 10 percent of used gasoline vehicles that would be provided by buyers participating in the program would have been scrapped without the program, suggesting a low degree of non-additionality for the vehicle scrappage aspect of the program.

Fourth, we model interactions that the program would have with the used vehicle market to measure the extent to which program effects are offset or “leaked away” by equilibrium price
adjustments (Jacobsen and van Benthem 2015). We find that the additional vehicle scrappage caused by the program would reduce the supply of used vehicles by 0.4 percent and increase average used vehicle prices by 1 percent. This price increase would reduce the rate of vehicle scrappage as more vehicle owners would find it worthwhile to make repairs to their more valuable vehicles (Parks 1977; Jacobsen and van Benthem 2015). We calculate that about 14 percent of the additional vehicles scrapped under the program would be offset by delayed scrappage induced by used vehicle price increases. Thus, our calculations suggest that the program would lead to a substantial quantity of equilibrium gasoline vehicle scrappage, since around 86 percent of scrapped vehicles would be additional.

Fifth, we find that increasing the subsidy amount in the linked policy can achieve comparable EV sales and greater purchase additionality relative to the unlinked policy. We find that approximately doubling the subsidy payment per vehicle can more than offset the additionality effects that trade-in opportunity costs have on program participation. Our analysis highlights the importance of accounting for opportunity costs to achieve sales and spending objectives.

Our work is related to several areas of policy analysis and literature. Current policies for promoting EV adoption include state-level sales mandates and financial subsidies at the state and federal levels. The current federal subsidy provides buyers of certain EVs with up to a $7,500 tax credit. This subsidy has been phased out for two of the highest selling EV manufacturers, General Motors and Tesla, due to a sales cap of 200,000 units. One common criticism of this tax credit is additionality—the credit has gone to households that would have bought an EV without the credit. Xing et al. (2021) find that from 2012 to 2014, only about 30 percent of purchases were additional, with the remaining 70 percent of credits going to households that would have bought an EV without the subsidy. Their study is based on an estimated discrete choice model of vehicle demand using purchase data from 2010 to 2014. The market for EVs has changed considerably since 2014, with introductions of mass-market EV models such as the Tesla Model 3 in 2018. This introduction likely has drawn a different group of new vehicle buyers that could have distinct preferences relative to buyers from 2014. Our analysis addresses this issue by using more recent data from 2018, which includes Tesla Model 3 purchases. Furthermore, in addition to quantifying the degree of additionality for an EV purchase subsidy, we compare this policy instrument with one that links the subsidy to a gasoline vehicle scrappage requirement.

Another criticism of the current tax credit is that the credit does not address stock turnover. What matters for attaining greenhouse gas (GHG) reduction goals is emissions from the entire passenger vehicle stock, and not just emissions from new vehicles. New vehicles represent only about 5 percent of the entire on-road vehicle stock. The current federal tax credit only applies to new EVs, and does not provide financial incentives to reduce the existing stock of gasoline vehicles. Achieving short-run
reductions in total fleet emissions, therefore, would likely require addressing how quickly new vehicles replace the used vehicle stock.

Linking a new vehicle purchase choice with a used vehicle scrappage requirement has been adopted in prior policies to accelerate stock turnover. Namely, Cash for Clunkers provided cash vouchers for buyers of new cars who chose relatively fuel-efficient new vehicles and provided a sufficiently low fuel economy used gasoline vehicle to scrap. The stated environmental goal of the policy was to reduce gasoline consumption by increasing the share of high fuel economy vehicles in the fleet. Li et al. (2013) found that the policy did increase new vehicle sales and reduced GHG emissions, but at a relatively high cost per ton of carbon dioxide ($CO_2$) reduced. Furthermore, the study found that 45 percent of the subsidy funds went to consumers that would have purchased a new vehicle anyway, suggesting that the policy suffered from a significant degree of non additionality. The authors note that their results highlight the difficulty of achieving two objectives—providing economic stimulus and reducing pollution—with a single instrument. The Schumer plan that we analyze has a similar, albeit more aligned set of objectives—increasing the share of new EVs sold, and accelerating the rate of used gasoline vehicle scrappage. Our analysis also highlights the difficulty of achieving these two objectives with a single linked policy.

Our work is also related to the literature on additionality in environmental subsidy programs. The literature on carbon offsets programs explores how different policy instruments can address additionality concerns. Some of the offsets literature focuses on how to set offset project baselines to balance additionality and economic efficiency trade-offs: making program baselines more stringent generally lowers the degree of additionality, but can also lower economic efficiency (van Benthem and Kerr 2013; Bento et al. 2015). Our analysis identifies how linking brings about a unique trade-off between additional purchases and additional scrappage decisions: linking lowers purchase additionality but leads to a high degree of additional scrappage.

The environmental subsidy literature also identifies a relationship between the magnitude of a subsidy and the amount of program participation. Bento et al. (2016) find that with high carbon prices, additionality concerns become less severe since more projects supply undercredited emissions reductions. Boomhower and Davis (2014) estimate additionality in a subsidy program in Mexico and find that program participation increases with a larger subsidy. We find a similar result in our context, since linking lowers the effective subsidy and lowers the percentage of additional purchases.
We explore beyond this relationship, however, by measuring multiple forms of additionality, finding a more nuanced association between them and the subsidy amount.

2 Description of the Schumer Clean Cars for America plan

In 2019, Senator Chuck Schumer proposed a Clean Cars for America plan which would require trading in an old gasoline vehicle to be scrapped to acquire a voucher that could be applied toward purchasing a new EV or other clean vehicle. The intent of the program would be to reduce GHG emissions by replacing 63 million gasoline vehicles or approximately 25 percent of the stock with clean vehicles. The program would be funded with $392 billion over a 10 year period, or an average of $39.2 billion per year. To put this funding in perspective, the 2009 Cash for Clunkers program had a budget of $3 billion over a one-month period, which would have translated to $36 billion had it lasted for a full year or $360 billion over 10 years.

The essential feature of the program would involve a cash voucher that could be applied to a plug-in electric, plug-in hybrid, or hydrogen fuel cell vehicle purchase. The amount of the rebate would depend on several factors. It would start at a base amount of $3,000 and increase based on the battery range of the vehicle. Buyers with incomes less than or equal to 200 percent of the federal poverty line would be eligible for an additional $2,000 toward a new vehicle purchase. Bonuses to the base voucher amount would include an additional 50 percent for vehicles built in the United States with strong labor standards and $500 for vehicles with 50 percent domestic content and a US-manufactured battery.

To obtain a purchase subsidy voucher, buyers would be required to trade in a gasoline vehicle in driving condition that was at least 8 years old. Buyers would take their used vehicle to a dealer or registered business that would scrap the vehicles. Each buyer would only be eligible for one voucher.

3 Data

The primary data come from the InMoment New Vehicle Customer Survey (NVCS). InMoment contacts new vehicle buyers from all over the United States each year to gather information about the vehicles consumers purchased, transaction and financing details, shopping experience, demographics and preference information, and so on. We use the 2018 wave of the survey with purchases that occurred from October 2017 through September 2018.

The NVCS includes basic vehicle purchase information (e.g., make, model, fuel type, actual transaction price) that we use to identify whether a consumer purchased a clean vehicle. This

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4This additional sum could be substituted for a 20 percent rebate to purchase used vehicles built prior to the program taking effect. Since our modeling framework is static, we do not consider this used vehicle portion of the subsidy design.
information is critical for identifying consumers as additional or non-additional under the Schumer plan. Importantly, NVCS also includes trade-in details for consumers who disposed of a vehicle at the time of purchase. From the survey, we know the make, model, age, fuel type, and disposal method (e.g., traded in at purchase, sold to used vehicle dealer, sold for scrap) of each vehicle. This allows us to identify which consumers would be eligible to participate in the Schumer program based on the age and fuel type of their disposed vehicle.

The 2018 InMoment NVCS contains 256,169 new vehicle purchase or lease transactions. We drop 49,658 transactions that did not respond to the vehicle disposal questions on the survey and 28,843 transactions by those that reported disposing of a leased vehicle, leaving us with 177,668 transactions for our analysis.\(^5\) We use survey weights provided in the NVCS that are intended to be representative of national US new vehicle sales.\(^6\) The survey weights total around 8.6 million purchases (after dropping the previously mentioned records), and we scale these up on a proportional basis to increase the total number of transactions to around 14.7 million purchases, which represent about 85 percent of the 2018 US new vehicle market.\(^7\) We use simple regressions and averages to impute missing values for consumer household income, disposed vehicle trade-in value, new vehicle purchase price, and trade-in age.\(^8\) To maximize potential participation in the Schumer program, we assume any vehicle purchases that are missing fuel type are gasoline-powered.

Finally, for the analysis of the equilibrium effects of scrappage induced by the Schumer program, we use an equilibrium model calibrated with data from the 2017 wave of the National Household Travel Survey.\(^9\)

\(^5\) Buyers who dispose of leased vehicles would not be eligible for the Schumer plan since they do not own the vehicles they are turning in.

\(^6\) A restriction of the sampling method used by InMoment is that a set manufacturers are not present in a select number of states. BMW, Jaguar-Land Rover, Mercedes Benz, MINI, Porsche, Smart, and Tesla purchase or lease transactions are not sampled by InMoment in the following states: Alaska, Arizona, California, Hawaii, Illinois, Kansas, Maryland, Montana, Nevada, New Hampshire, New York, Oregon, Pennsylvania, South Dakota, and Washington. Given this sampling limitation, we focus our analysis on national level outcomes.

\(^7\) The remaining 15 percent that we omit represent fleet sales. The aggregate market statistics we use to scale up the InMoment weights can be found here.

\(^8\) We impute household income, vehicle purchase price, and trade-in value using averages from the rest of the sample. For purchase price and trade-in value, we calculate this average from among vehicles with similar model year, make, model, and fuel type and then from higher level groupings (e.g., model year, make, model) where necessary. For any remaining missing trade-in values, we use simple linear regression to impute the remaining values. We also use simple linear regression to impute missing trade-in vehicle ages. The regression results for the imputations are available from the authors upon request.

\(^9\) Calculations of the equilibrium model are made based on elasticities estimated in Leard et al. (2019) and a series of assumptions to convert them to the used vehicle market. The authors have documentation of this calibration process that is available upon request.
4 Modeling assumptions

4.1 Clean vehicle purchases

We simulate the one-year effects of the Schumer plan using a vehicle choice and trade-in model calibrated with 2018 InMoment survey data. Our approach is straightforward and uses simple modeling assumptions. First, we identify the households in the survey who are both eligible and incentivized to participate based on whether or not they disposed of a vehicle at the time of purchase and the age, fuel type, and value of their trade-in. Second, we calculate changes in predicted market share, which we denote as purchase probability, based on the price reduction implied by participating in the Schumer plan. Importantly, this price reduction is the effective subsidy—the difference between the subsidy amount and the disposed vehicle’s trade-in value. The effective subsidy takes into account the opportunity cost of participating in the program versus simply selling or trading in a vehicle in the conventional way, since buyers do not receive the trade-in value if they participate in the Schumer plan. Thus, we define a household as eligible to participate in the program if it disposes of a vehicle that is at least 8 years old and is gasoline or diesel-powered, and we define a household as incentivized to participate if the Schumer subsidy is greater than the disposed vehicle’s trade-in value. Table 1 shows the basic eligibility criteria for participating in the Schumer plan, along with the gross subsidy amounts we use in our analysis. For comparison, Table 3 shows that the average effective subsidy is $2,960, which is lower than the gross subsidies.

To calculate changes in clean vehicle purchase probabilities, we assume a constant elasticity of demand which allows us to relate clean car purchase probabilities to prices as follows:

\[
\ln(M^0) = \mu_i \ln(P) + c_i. \tag{1}
\]

In equation (1), \(M^0\) is the baseline market share of clean cars from the InMoment data, \(\mu_i\) is the price elasticity of demand for consumer \(i\), \(P\) is the clean car purchase price, and \(c\) is a constant. As indicated in Table 2, we assume a price elasticity of \(-5\) for low-income consumers and \(-3\) for all other consumers.\(^{10}\) Rearranging equation (1), we can solve for the constant for each consumer:

\[
c_i = \ln \left( \frac{M^0}{e^{\mu_i \ln(P)}} \right).
\]

\(^{10}\) Low-income consumers represent fewer than 2 percent of the InMoment observations in our analysis. We expect low-income consumers to be more price sensitive than the typical new car buyer in the sample. We identify households as low-income using US Census poverty thresholds based on the number of children and household sizes. The thresholds can be found here: https://www2.census.gov/programs-surveys/cps/tables/time-series/historical-poverty-thresholds/thresh18.xls
Once we have the constant, we compute the new predicted market share assuming a reduced purchase price of a clean vehicle in the amount of the Schumer plan rebate:

$$M_i^1 = e^{\mu_i \ln (P - S_i)} \cdot e^{c_i}.$$  \hspace{1cm} (2)

In equation (2), $M_i^1$ is the eligible and incentivized household-specific new clean car purchase probability and $S_i$ is the effective subsidy each consumer receives based on their individual trade-in. The difference $M_i^1 - M^0$ is the implied increase in purchase probability for each eligible and incentivized household due to the Schumer plan. We multiply these probability increases by the US market new vehicle sales to compute the predicted increase in new clean car purchases under the Schumer plan. This increase represents additional purchases under the program.

To measure the degree of purchase additionality, we first define the amount of subsidy dollars going to additional and non-additional purchases. Denoting total new vehicle purchases made by eligible and incentivized households as $N$, total subsidy dollars spent is

$$\sum_{i=1}^{N} M_i^1 \ast S_i.$$  \hspace{1cm} (3)

Subsidy dollars going to additional buyers are

$$\sum_{i=1}^{N} (M_i^1 - M^0) \ast S_i$$  \hspace{1cm} (4)

and subsidy dollars going to non-additional buyers are

$$\sum_{i=1}^{N} M^0 \ast S_i.$$  \hspace{1cm} (5)

Table 2 shows some basic market statistics and assumptions used in our analysis. We use a baseline clean vehicle market share of $M^0 = 2.14$ percent from the InMoment survey. Additionally, Table 2 shows that, among the 14.7 million new vehicle purchases made by households in 2018, only around $N = 3.5$ million are potential additional new clean vehicle buyers after accounting for eligibility and incentive effects.
4.2 Scrappage and equilibrium effects

Besides computing expected increases in clean car purchases, we also compute expected additional scrappage under the Schumer plan, since one of the main benefits of the program is to accelerate the scrappage of gasoline vehicles. We use disposal methods reported in the InMoment survey to infer additional versus non-additional scrappage under the Schumer plan. The survey asks respondents to provide information on a disposed vehicle, including model year, make, model, series, fuel type, mileage, whether it was purchased or leased, and other details. The survey also asks respondents to report the method of disposal (e.g., traded in, sold for scrap, donated to charity) as well as the trade-in value if the respondent traded in the vehicle. We use this information to determine eligibility and incentives for participation in the Schumer program, as well as whether the disposed vehicle represents additional or non-additional scrappage. We discuss this further in the sections that follow.

Finally, we also compute the potential equilibrium effects of additional scrappage in the used vehicle market. Additional scrappage will reduce the supply of used vehicles, which may cause equilibrium prices of these vehicles to increase. Since scrappage is a function of a vehicle’s value, these price increases will reduce the scrappage likelihood for remaining vehicles in the used supply, which will dampen the effects of the scrappage we predict under the Schumer plan. To calculate this dampening effect, we apply the additional scrappage figures from our main simulation proportionally across used vehicle variants based on vehicle age, type (e.g., sedan, SUV), and fuel type. We then use the used vehicle equilibrium model developed in Ankney et al. (2022) to calculate the implied price increases for these vehicles and the resulting reduction in expected scrappage based on a calibrated scrappage equation taken from Jacobsen and van Benthem (2015). One can think of this as a “scrappage rebound effect” or “Gruenspecht effect,” where the reduction in supply of used vehicles actually reduces the scrappage rates for the remaining used vehicles in the supply.

To calculate the dampening effect of scrappage in the used vehicle market, we use aggregate demand elasticities calibrated from the used vehicle market equilibrium model in Ankney et al. (2022). The aggregate demand elasticity $\psi_j$ of vehicle $j$ is defined as the percentage change in quantity demanded in response to a one percent increase in prices of all used vehicles in the market. Essentially, this is the demand response to a price increase of all used vehicles that we calculate for each used vehicle variant in our sample. We compute $\psi_j$ by simulating a new equilibrium using the model from Ankney et al. (2022)—the average aggregate demand elasticity is $-1.5$.11

11There are 137 used vehicle variants in the equilibrium model from Ankney et al. (2022). The vehicles are defined based on age, vehicle type (e.g., sedan, SUV), and fuel type. Of these 137, 85 of them appear in our population of additional scrapped vehicles from the Schumer analysis. This covers most used vehicle variants in the model that would be eligible for the Schumer plan as trade-ins (i.e., at least 8 years old and gasoline-powered). We use these 85 vehicle variants only—not the entire used vehicle market—to calculate the equilibrium effects of scrappage due to the Schumer plan. More details on the equilibrium model are available from the authors upon request.

12Aggregate elasticity values at the vehicle variant level are available from the authors upon request.
As mentioned above, we take the additional scrapped vehicles from our Schumer plan simulation and assign them proportionally to the used vehicle variants in our sample. These additional scrapped vehicles effectively reduce the supply of each used vehicle variant by the amount of the additional scrappage. We compute the percent change in supply of each vehicle based on this reduction and then use the standard definition of price elasticity of demand to compute the implied percentage change in equilibrium prices due to the supply decrease:

$$\psi_j = \frac{\% \Delta Q_j}{\% \Delta P_j},$$

which after rearranging yields

$$\% \Delta P_j = \frac{\% \Delta Q_j}{\psi_j}.$$

(6)

Given the price changes calculated for each vehicle variant in equation (6), we compute revised equilibrium prices relative to the baseline equilibrium from [Ankney et al. (2022)] and use these revised prices to compute new vehicle scrappage totals. Finally, we compute the difference between baseline equilibrium scrappage and post-Schumer program scrappage and aggregate across the used vehicles. This aggregate change in scrappage approximates the equilibrium offset in scrappage we might expect due to the Schumer plan’s effect on used vehicle prices.

4.3 Caveats and further discussion

Given that our data only include a cross section of survey responses, we do not model inter-temporal purchase decisions. In the short run, this dimension of consumer behavior could be relevant. Li et al. (2013) found that the Cash for Clunkers program pulled sales from prior and future months, leading to an increase in total new vehicle sales during the single month that the program ran. However, they found no increase in sales within a 6-month period surrounding the program, suggesting that the program had a limited impact based on a longer time horizon. Since the Schumer plan was written to last 10 years, we would expect a similar small or zero effect on total new vehicle sales over that time horizon.

Furthermore, our data only include survey responses from new vehicle buyers. We therefore focus our analysis on how new vehicle buyers would respond to the subsidy programs by substituting between new vehicle types (e.g., gasoline and electric). The subsidy could draw used vehicle buyers to the new

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13[Ankney et al. (2022)] use a vehicle scrappage rate function of the form \( y_j = b_j p_j^{\gamma_j} \), where \( y_j \) is a vehicle’s scrappage rate, \( b_j \) is a calibration parameter, \( p_j \) is the vehicle’s equilibrium price, and \( \gamma_j \) is the scrappage elasticity, which we assume to be \(-0.7\) for all vehicles following Jacobsen and van Benthem (2015). As a vehicle’s equilibrium price increases, it becomes more valuable to hold and thus its scrappage rate declines.
vehicle market. However, new and used vehicle buyers generally have quite different preferences; for example, used vehicle buyers tend to buy the vehicles they buy because they are much more affordable than new vehicles. New vehicles have remained much more expensive than used vehicles: the average new vehicle price in 2022 was $47,000.\(^{14}\) In contrast, the average used vehicle price in 2022 was $28,000.\(^{15}\) Although an EV subsidy design such as the Schumer plan would somewhat reduce that difference, used vehicles would still remain much more affordable than new vehicles, suggesting a limited response by used vehicle buyers. Moreover, we would expect this substitution effect to be somewhat temporary, as the used vehicle market would eventually adjust to this substitution through changes in used vehicle prices, which would partially mitigate any substitution effects. This is especially the case because the Schumer plan would last 10 years. After one year, new vehicles bought under the program would become one year old used vehicles, and their market prices would reflect the up front discount resulting from the subsidy payment when the vehicle was purchased new.

## Results

### 5.1 Classifying buyer types

Figure\(^{16}\) groups new vehicle buyers who purchased a gasoline-powered vehicle into categories based on our data and modeling approach.\(^{16}\) The Schumer plan, by imposing several requirements for buyers to receive the subsidy, limits who is eligible. Among all new vehicle buyers in our data who did not, 45.3 percent had a trade-in gasoline vehicle that was under 8 years of age. These buyers would be ineligible to participate in the program, which requires trading in a gasoline vehicle that is 8 years old or older. Another 21.4 percent of new vehicle buyers did not dispose of any vehicle when they bought their new vehicle, making them ineligible as well. Furthermore, 10.3 percent of all buyers traded in an eligible 8 year old or older gasoline vehicle that was more valuable than the subsidy payment. These buyers would not participate in the program given the financial comparison between opting in to the program and not participating. Simply trading in their vehicle to a dealer would be more valuable than participating in the program. Only a small sliver of buyers report trading in an EV, so those households would also be ineligible. The remaining 22.9 percent of households—those that would be eligible and financially incentivized to participate—define a group of additional buyers under the Schumer plan that have the potential to opt in to the program. In sharp contrast, 100 percent of households under the pure subsidy program have the potential to opt in to the subsidy program. In summary, the design of the Schumer plan significantly reduces the number of possible buyers that

\(^{14}\)For example, see [https://www.kbb.com/car-news/average-new-car-price-tops-47000/](https://www.kbb.com/car-news/average-new-car-price-tops-47000/)

\(^{15}\)See, for example, [https://www.kbb.com/car-news/average-used-car-price-now-over-28000/](https://www.kbb.com/car-news/average-used-car-price-now-over-28000/)

\(^{16}\)This also includes diesel and hybrid vehicles and represents the population of potentially additional clean vehicle buyers under the Schumer plan.
the program would influence, suggesting that it would have a limited impact on increasing new EV adoption.

5.2 Main results

We report quantitative results in Table 3. The first three columns in the table represent simulated outcomes for three programs: the Schumer plan that links the EV purchase subsidy with a gasoline vehicle trade-in and scrappage requirement, a stand-alone EV purchase subsidy, and the Schumer plan after incorporating used vehicle market price effects from additional scrappage.\footnote{The third column essentially re-simulates the Schumer program after accounting for the fact that additional scrappage under the Schumer program will increase prices of used vehicles and thus make trade-ins more valuable. This in turn increases the opportunity cost of participation in the Schumer program. We discuss the third column further in the context of the additional scrappage analysis in Section 5.3 below.} To make the policies as comparable as possible, we set all parameters of the policies the same—such as the subsidy amount and conditions that increase the subsidy amount as explained in the prior section—except that the Schumer plan requires buyers to trade in a gasoline vehicle which is then scrapped.

In Panel (a), we report subsidy payments, costs, sales, and scrappage effects. The first row in Table 3 is the average gross subsidy per household. The values under all three programs are at or around $5,100, and are only slightly different because the policies draw in a different group of buyers due to the additional constraints imposed by the Schumer plan. New vehicle buyers under the pure purchase subsidy respond to the average gross subsidy according to our assumption about the own-price elasticity of demand. We calculate that a pure subsidy would reduce the purchase cost of EVs by about 12 percent, resulting in an increase EV sales of 46 percent relative to a no subsidy setting.

New vehicle buyers respond differently to the subsidy under the Schumer plan. Instead of responding to the average gross subsidy, they respond to an average effective subsidy, which subtracts from the gross subsidy the trade-in value of the eligible disposed gasoline vehicle that is turned in to receive the subsidy. The average effective subsidy is just under $3,000, which is significantly lower than the average gross subsidy. This represents a 7 percent reduction in the purchase cost of an EV.

The expected increase in EV sales is substantially lower under the Schumer plan: we find that the plan would increase sales by about 6 percent. This small effect is due to two reasons. First, as illustrated in Figure 1, only about one in five potential new EV buyers would be eligible for and incentivized to consider participating in the Schumer plan. This is in contrast to 100 percent of new vehicle buyers considering participating in the pure purchase subsidy program. Second, the average effective subsidy is much less than that average gross subsidy. This is because the effective subsidy accounts for the opportunity cost measured by the value of the vehicle traded in under the Schumer plan.
Over a 10 year period, we project that subsidy payments would total about $5 billion under the Schumer plan and $23 billion under the pure purchase subsidy. The $5 billion amount is tiny in comparison to the stated Schumer plan budget of $392 billion. Total vehicle scrappage under the plan would be 920,020 over a 10 year period, which also appears to fall well short of the plan’s goal of scrapping 63 million vehicles. A significant caveat to our analysis worth mentioning here is that our simulation results are based on a market share for new EVs of around 2 percent and an average own-price elasticity of -3. For a given price elasticity, plan expenditures and resulting scrappage would be much larger if the market share were bigger. For example, if the EV market share were 50 percent, we calculate that expenditures under the Schumer plan would be on the order of 75 billion over a 10 year period, with accompanying scrappage being 22 million vehicles.\(^{18}\) These values appear in the same magnitude as the Schumer plan goals, although they still fall short.

In Panel (b) of Table 3, we report key statistics summarizing results for additionality. For the pure subsidy policy, 33 percent of subsidy dollars go to additional households that would not have bought an EV without the subsidy. This is a similar magnitude reported in Xing et al. (2021), finding that 30 percent of EV tax credits went to additional households. In contrast, we find that for the Schumer plan, only 23 percent of subsidy dollars are obtained by additional households. Additionality is lower for the Schumer plan because the effective subsidy for this policy is lower than the gross subsidy in the pure subsidy policy as shown in Panel (a) of Table 3. Linking the subsidy with a vehicle scrappage requirement causes buyers to account for the trade-in opportunity cost that is subtracted from the gross subsidy, which provides a lower net incentive to change their behavior and buy an EV. The lower the financial incentive, the lower the degree of additionality, holding all other factors constant.\(^{19}\)

As a result, the subsidy dollars spent per additional clean car sold is higher under the Schumer plan—about $23,758 per vehicle, versus a cost of around $16,266 per vehicle under a stand-alone subsidy.

### 5.3 Additional scrappage results

Table 4 details the reported disposal methods of vehicles for eligible and incentivized households under the benchmark Schumer plan. We classify the “sold for scrap” category as non-additional

\(^{18}\)Please contact the authors to request these additional calculations.

\(^{19}\)This general result can be illustrated with a simple example. Suppose in a given year, one million EVs are sold and these purchases are made without policy support. These one million sales represent business-as-usual purchases. Further suppose a policy subsidizes the purchase of EVs, initially starting at $2,000 per EV. With this small incentive, EV sales increase by 0.2 million to 1.2 million, implying that 0.2/1.2 = 17 percent of subsidy dollars go toward additional purchases (with the remaining 83 percent going to non-additional buyers). One year later, the subsidy amount is increased to $5,000 per EV. EV sales increase by 0.5 million (relative to a no policy setting) to 1.5 million, implying that 0.5/1.5 = 33 percent of subsidy dollars go toward additional purchases (with the remaining 67 percent being non-additional). One final policy adjustment is made to increase the subsidy to $10,000 per EV. EV sales increase by 1.7 million to 2.7 million, implying that 1.7/2.7 = 63 percent of subsidy dollars go toward additional purchases. We can see here that as the subsidy amount increases, the fraction of subsidy dollars spent on additional purchases increases.
scrapage, since these consumers would have scrapped their vehicle anyway. To be conservative, we include non-responses in the non-additional scrapage population so as to not overstate expected potential additional scrapage. We also exclude from our analysis entirely any buyers who responded with “turned in/lease expired” or indicated elsewhere that their disposed vehicle were leased. These three categories imply non-additional scrapage due to the Schumer plan of 9.6 percent, meaning around 90.4 percent of scrapage under the program is additional. Based on these statistics, a majority of the scrapped vehicles under the Schumer plan appear to be additional scrapage.

5.4 Decomposing differences in outcomes

In Table 5, we decompose the effects that differences between the Schumer Plan and the stand-alone EV subsidy have on the total number of additional EV purchases made. The first row shows the sales response from a subsidy to all buyers, denoted as the baseline under the “characterization” column. We then add in one at a time requirements and constraints imposed by the Schumer plan in rows below. The second row shows the effect of the plan requiring a trade-in vehicle. This reduces the number of additional purchases by about 33,000 vehicles, or 23 percent. The third row further reduces the number of additional purchases due to the requirement that the trade-in vehicle must be a gasoline vehicle that is 8 years old or older. This feature dramatically reduces the sales increase by about 60,000 purchases relative to the second row. The fourth row shows the reduction of the sales impact due to the opportunity cost of the trade-in decision. Buyers that own a trade-in gasoline vehicle that is worth more than the trade-in amount will not be willing to participate in the program, since it is more profitable for them to simply trade in their vehicle the conventional way. This reduces the sales impact by about 16,000. The remaining difference between the sales impact in the bottom row and the additional vehicles sold as reported in Table 3 is due to the feature that some of those remaining are not going to participate because of the difference between the value of the subsidy payment and the trade-in opportunity cost difference. The effective subsidy payment is about 40 percent less than the subsidy without linking, and this difference further reduces the number of additional EV sales under the Schumer plan.

5.5 Accounting for equilibrium price changes when measuring scrapage effects

We next evaluate how the scrapage effects from the Schumer plan might interact with the used vehicle market. By removing gasoline vehicles from the stock, the plan shifts inward the supply of used vehicles, which is expected to raise used vehicle prices. As a result, used vehicle scrapage will slow down (Jacobsen and van Benthem 2015). This slowdown can offset the degree to which gasoline vehicles are scrapped under the plan. We quantify the magnitude of this equilibrium price effect by
combining our vehicle scrappage calculations with a set of assumptions about the used vehicle price elasticity of demand (see Panel (b) in Table 2), data on used vehicle purchases inferred from the 2017 National Household Travel Survey, and assumptions for the used vehicle scrap elasticity (Jacobsen and van Benthem 2015). Note that our calculation is static and we do not consider dynamic changes in the vehicle stock over time; we leave incorporating dynamic effects for future work. Also note that we do not consider the general equilibrium effect that adjusting used vehicle prices might have on the new vehicle market; this would require a fully specified producer supply and consumer demand system that is beyond the scope of the current analysis.

Table 6 shows the results from our analysis. The first row reports one year vehicle scrappage under the program. Since equilibrium price adjustments will only result from additional used vehicle scrappage, we report additional scrappage as 83,216 vehicles in one year. We calculate that the Schumer plan would result in a scrappage offset of 11,244 vehicles due to higher equilibrium used vehicle prices. This is a 14 percent offset or leakage effect, which is comparable to used vehicle leakage effects reported for fuel economy standards (Jacobsen and van Benthem 2015). Why do we see this leakage? Table 6 shows that the additional projected scrappage under the Schumer plan results in used vehicle prices increasing by an average of 1 percent. This price increase reduces the likelihood of consumers electing to scrap their older vehicles since scrappage likelihood is negatively correlated with a vehicle’s value. Nevertheless, while this magnitude is of leakage is nontrivial, our calculations imply that a large majority of additional scrappage induced by the Schumer plan would be realized.

One might be concerned that the increase in used vehicle prices from the additional scrappage just described would make consumers less likely to participate in the Schumer plan. After all, used vehicle price increases essentially increase the value of consumer trade-ins, thus increasing the opportunity cost—and reducing the effective subsidy—of participating in the Schumer program. We explore this feedback effect in a partial equilibrium setting by resimulating the Schumer program after adjusting trade-in values according to the implied equilibrium used vehicle price changes we reference in the previous paragraph.

Column (3) of Table 3 shows the revised Schumer program simulation results after incorporating these equilibrium used vehicle price effects into trade-in values. Column (3) of Table 3 shows that the simulation results are essentially unchanged from the baseline Schumer simulation in column (1). The average trade-in value is slightly higher—$2,138 versus $2,107—and the average effective subsidy is slightly lower, but overall new clean vehicle adoption is very similar, with only 201 fewer clean vehicles expected to be purchased after incorporating the feedback effects. Based on this, we do not anticipate

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20The trade-in price changes are merged with the InMoment data at the vehicle age, vehicle type, and fuel type level using the implied price changes calculated for the 85 used vehicle variants according to equation (6). For any InMoment trade-ins that fail to merge with these data, we assume a price increase of 1 percent.
that equilibrium price effects of used vehicles would have a significant impact on participation in the Schumer program.

Our results are somewhat consistent with evidence on the effect of scrappage programs on used vehicle prices. [Busse et al. (2012)] find that the Cash for Clunkers program did not raise equilibrium prices of used vehicles. Although we simulate that the Schumer plan would increase used vehicle prices, we find a minor price increase, which is consistent with [Busse et al. (2012)].

5.6 Schumer plan with a larger subsidy

In column (4) of Table 3, we report simulation results for a scaled up version of the Schumer plan, where the subsidy payment is increased to the point where total spending is identical to the subsidy dollars spent under the stand-alone EV purchase subsidy ($2.3 billion per year). The average gross subsidy for each participating household becomes $12,910, which is more than double the amount for either of the other policies. After accounting for the opportunity cost of the trade-in vehicles, this subsidy represents a 24.3 percent price reduction for EVs, which is about twice as large of a reduction as EV subsidy to all buyers. EV sales increase by 34.6 percent under this scaled up policy, which is nearly six times as large as the benchmark Schumer plan. This increase, however, is smaller than the increase we find for the stand-alone EV subsidy. The smaller sales effect is due to the eligibility requirements imposed by the Schumer plan. As illustrated in Figure 4, the requirements severely restrict the population that can take up the subsidy, making it more expensive per vehicle sold to encourage additional EV purchases. The degree of purchase additionality, however, considerably improves under the scaled up plan. Panel (b) reports that the percentage of subsidy dollars going to additional households is 61 percent under the scaled up Schumer plan. This is nearly double the degree of additionality of the stand-alone EV subsidy. The scaled up Schumer plan provides about double the effective subsidy to eligible households relative to the stand-alone EV subsidy. As a result, more additional households participate relative to total participation. Therefore, concerns about purchase additionality could be reduced by raising the subsidy amount per vehicle.

6 Conclusion

Although our results are based on a particular proposal that links an EV purchase subsidy with a gasoline vehicle scrappage requirement, they provide insights for explaining results from prior programs linking new vehicle purchase subsidies with vehicle scrappage. In particular, our results explain findings from prior studies looking at the Cash for Clunkers program. Both [Mian and Sufi (2012)] and [Li et al. (2013)] find that the program had a small or close to zero impact on new vehicle purchases over a 6 to 12 month time period surrounding the program window. Our results suggest that this could be explained by the opportunity cost of the trade-in vehicle—requiring a trade-in
that would then be scrapped eliminates a large number of people from being willing to participate in
the program, since many people have trade-in vehicles that are valued more than the amount of the
subsidy. As we see in our analysis, this opportunity cost dramatically reduces the new vehicle sales
impact of the Schumer plan. Had Cash for Clunkers been designed without a link between the new
vehicle purchase and the scrappage requirement, the program could have led to a much larger impact
on sales.

Furthermore, prior studies have focused primarily on how linked programs affected new vehicle
purchases and less so on the vehicle scrappage component of the program. Our results indicate that
the Schumer plan appears to have a high degree of scrappage additionality, where a large majority of
used gasoline vehicles scrapped under the plan would be traded in and likely resold on the used vehicle
market without having the plan in place. Cash for Clunkers led to 677,842 vehicles being scrapped
during its one-month implementation (GAO, 2010). If Cash for Clunkers also had a high degree of
scrappage additionality, a majority of these scrapped vehicles could have remained in the on-road
stock had the program not been implemented, suggesting that the program was effective at increasing
stock turnover. Our analysis motivates future research that separately measures new vehicle sales and
used vehicle scrappage effects of linked programs.

Our results paint a mixed evaluation of linking EV purchase subsidies with gasoline vehicle
scrappage requirements. On the one hand, our purchase additionality results suggest that linking
increases the subsidy cost per additional EV sold, as a greater share of payments would go to buyers
that would have bought new EVs anyway relative to a pure purchase subsidy. However, we find that
approximately doubling the size of the subsidy under the Schumer plan can effectively address this
concern, since doing so counteracts the additionality effects of trade-in vehicle opportunity costs.
Therefore, policy makers concerned with purchase additionality could consider increasing the amount
of the subsidy payment. Furthermore, the scrappage additionality results for the benchmark Schumer
plan appear to be effective at accelerating the rate at which the passenger vehicle stock turns over. In
this light, policies with similar characteristics to the Schumer plan may more appropriately be viewed
as a promising way to speed up vehicle scrappage, with an extra benefit of encouraging a modest
number of additional new EV purchases. Therefore, combining complementary policies with linked
subsidy policies that can increase the adoption of new EVs, such as subsidies for charging station
infrastructure, is likely necessary for achieving US decarbonization goals.
References


7 Figures

Figure 1: Disposed vehicles for households that purchased a gasoline vehicle

**Notes:** This figure includes hybrid and diesel-powered vehicles. Data are taken from 2018 InMoment respondents who purchased a gasoline, diesel, or hybrid vehicle. This represents the population of new vehicle buyers who could potentially be incentivized to participate as an additional EV buyer under the Schumer plan.
8 Tables

Table 1: Schumer program subsidy and eligibility description

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsidy value (base)</td>
<td>$3,000</td>
</tr>
<tr>
<td>Subsidy increase (US labor and parts)</td>
<td>$2,000</td>
</tr>
<tr>
<td>Assumed total base subsidy</td>
<td>$5,000</td>
</tr>
<tr>
<td>Assumed subsidy (low-income households)</td>
<td>$8,000</td>
</tr>
<tr>
<td>Trade-in age requirement</td>
<td>8 years or older</td>
</tr>
</tbody>
</table>
Table 2: Market stats, key parameters and assumptions

### Panel (a): 2018 new vehicle market snapshot

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total purchases</td>
<td>14,683,113</td>
</tr>
<tr>
<td>Clean car purchases</td>
<td>314,766</td>
</tr>
<tr>
<td>Clean car market share</td>
<td>2.14%</td>
</tr>
<tr>
<td>Average clean car purchase price</td>
<td>$43,789</td>
</tr>
<tr>
<td>Total trade-ins</td>
<td>8,532,252</td>
</tr>
<tr>
<td>Schumer-eligible trade-ins</td>
<td>3,400,682</td>
</tr>
<tr>
<td>Average trade-in age (years)</td>
<td>7.9</td>
</tr>
<tr>
<td>Average trade-in value</td>
<td>$9,942</td>
</tr>
<tr>
<td>Total disposed vehicles</td>
<td>11,269,893</td>
</tr>
<tr>
<td>Total eligible and incentivized households</td>
<td>3,620,571</td>
</tr>
<tr>
<td>Non-additional eligible and incentivized households</td>
<td>72,246</td>
</tr>
<tr>
<td>Potential additional eligible and incentivized households</td>
<td>3,548,325</td>
</tr>
</tbody>
</table>

### Panel (b): Simulation parameters and assumptions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Assumption/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low income price elasticity of demand (new vehicles)</td>
<td>−5</td>
</tr>
<tr>
<td>All other households price elasticity of demand (new vehicles)</td>
<td>−3</td>
</tr>
<tr>
<td>Average price elasticity of demand (new vehicles)</td>
<td>−3.1</td>
</tr>
<tr>
<td>Average aggregate used vehicle market elasticity</td>
<td>−1.5</td>
</tr>
</tbody>
</table>

Notes: This table reports some basic market statistics for sales and clean vehicle market shares from the 2018 InMoment survey, along with assumed/calculated price elasticity of demand parameters used in the simulation analysis. The average aggregate used vehicle market elasticity uses the equilibrium model from Ankney et al. (2022) and averages the demand response to a 1 percent increase in all used vehicle prices.
Table 3: Main results — Schumer plan versus EV subsidy for all buyers

Panel (a) Subsidy payments, costs, sales and scrappage effects

<table>
<thead>
<tr>
<th></th>
<th>Schumer plan</th>
<th>EV subsidy to all buyers</th>
<th>Schumer with price effects</th>
<th>Schumer with larger subsidy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average gross subsidy per household</td>
<td>$5,102</td>
<td>$5,058</td>
<td>$5,101</td>
<td>$12,910</td>
</tr>
<tr>
<td>Average trade-in value among eligible and incentivized households</td>
<td>$2,107</td>
<td>N/A</td>
<td>$2,138</td>
<td>$2,107</td>
</tr>
<tr>
<td>Average effective subsidy</td>
<td>$2,960</td>
<td>$5,058</td>
<td>$2,927</td>
<td>$10,635</td>
</tr>
<tr>
<td>Average effective clean car price reduction</td>
<td>6.76%</td>
<td>11.6%</td>
<td>6.68%</td>
<td>24.3%</td>
</tr>
<tr>
<td>Expected clean car increase (additional households)</td>
<td>19,756</td>
<td>143,788</td>
<td>19,555</td>
<td>108,881</td>
</tr>
<tr>
<td>Overall clean car growth percentage</td>
<td>6.3%</td>
<td>45.7%</td>
<td>6.2%</td>
<td>34.6%</td>
</tr>
<tr>
<td>Total expected subsidy (billions)</td>
<td>$0.5</td>
<td>$2.3</td>
<td>$0.5</td>
<td>$2.3</td>
</tr>
<tr>
<td>10-year estimated program cost (billions)</td>
<td>$4.7</td>
<td>$23.4</td>
<td>$4.7</td>
<td>$23.4</td>
</tr>
<tr>
<td>10-year estimated vehicle scrappage total</td>
<td>920,020</td>
<td>N/A</td>
<td>918,010</td>
<td>1,811,270</td>
</tr>
</tbody>
</table>

Panel (b): Additionality results

<table>
<thead>
<tr>
<th></th>
<th>Schumer plan</th>
<th>EV subsidy to all buyers</th>
<th>Schumer with price effects</th>
<th>Schumer with larger subsidy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-additional households receiving subsidy</td>
<td>72,246</td>
<td>314,766</td>
<td>72,246</td>
<td>72,246</td>
</tr>
<tr>
<td>Total number of households receiving subsidy</td>
<td>92,002</td>
<td>458,554</td>
<td>91,801</td>
<td>181,127</td>
</tr>
<tr>
<td>Subsidy for non-additional households (billions)</td>
<td>$0.4</td>
<td>$1.6</td>
<td>$0.4</td>
<td>$0.9</td>
</tr>
<tr>
<td>Expected subsidy for additional households (billions)</td>
<td>$0.1</td>
<td>$0.8</td>
<td>$0.1</td>
<td>$1.4</td>
</tr>
<tr>
<td>Percentage of subsidies to additional households</td>
<td>23%</td>
<td>33%</td>
<td>23%</td>
<td>61%</td>
</tr>
<tr>
<td>Percentage of subsidies to non-additional households</td>
<td>77%</td>
<td>67%</td>
<td>77%</td>
<td>39%</td>
</tr>
</tbody>
</table>

Notes: This table compares the projected impact of the Schumer plan in column (1) with a blanket new clean car subsidy of $8,000 for low-income consumers and $5,000 for all other consumers in column (2). Column (3) incorporates equilibrium price effects on trade-in values resulting from implementation of the Schumer plan. Column (4) simulates a larger subsidy for the Schumer plan, increasing base and low-income subsidies by $7,675 relative to Column (1). This increase was calibrated such that the total spending on the program in Column (4) matched that of the flat EV subsidy in Column (2). The percentage of subsidies to additional households is calculated as the fraction of projected subsidy payments to additional clean vehicle buyers divided by the total expected subsidy payments made to both additional and non-additional buyers. Note here that additionality refers to clean vehicle purchases and not gasoline vehicle scrappage.
Table 4: Vehicle disposal methods for eligible and incentivized households

<table>
<thead>
<tr>
<th>Disposal method</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traded in on new vehicle</td>
<td>2,031,839</td>
<td>56.1%</td>
</tr>
<tr>
<td>Sold to private party</td>
<td>646,764</td>
<td>17.9%</td>
</tr>
<tr>
<td>Gave to friend or family</td>
<td>277,303</td>
<td>7.7%</td>
</tr>
<tr>
<td>No response</td>
<td>226,751</td>
<td>6.3%</td>
</tr>
<tr>
<td>Other</td>
<td>133,017</td>
<td>3.7%</td>
</tr>
<tr>
<td>Sold for scrap</td>
<td>119,191</td>
<td>3.3%</td>
</tr>
<tr>
<td>Donated to charity</td>
<td>105,841</td>
<td>2.9%</td>
</tr>
<tr>
<td>Sold to used vehicle dealer</td>
<td>79,865</td>
<td>2.2%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3,620,571</td>
<td>100%</td>
</tr>
</tbody>
</table>

Notes: In our analysis, we classified the “sold for scrap” and “no response” categories as business-as-usual scrappage behavior. Households that participate in the program belonging to this group represent non-additional scrappage, since these consumers would have scrapped their vehicles anyway. To be conservative, we included non-responses in the non-additional scrappage population so as not to overstate expected potential additional scrappage. These two categories imply non-additional scrappage due to the Schumer plan of 9.6%, meaning around 90.4% of scrappage under the program is additional. Additionally, while InMoment has around 200,000 purchases in our sample, we use survey weights to scale up the purchases to represent the entire US new vehicle market. The InMoment survey weights amount to around 8.6 million purchases, and we scale that up further proportionally to around 14.7 million purchases, which represents around 85 percent of the 2018 US new vehicle market (approximately 15 percent of the market is fleet sales, so we do not include those in our weighting). Aggregate market statistics can be found here.
Table 5: Decomposition of Schumer plan

<table>
<thead>
<tr>
<th>Decomposition: Benchmark to Schumer</th>
<th>Total purchases</th>
<th>Additional clean cars purchased</th>
<th>% Reduction</th>
<th>Characterization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting total: EV subsidy for all consumers</td>
<td>14,683,113</td>
<td>143,788</td>
<td>N/A</td>
<td>Baseline</td>
</tr>
<tr>
<td>Must trade in vehicle</td>
<td>11,269,893</td>
<td>110,363</td>
<td>23%</td>
<td>Disposal effect</td>
</tr>
<tr>
<td>Must own eligible trade-in</td>
<td>5,247,088</td>
<td>51,383</td>
<td>53%</td>
<td>Eligibility effect</td>
</tr>
<tr>
<td>Must be incentivized to participate</td>
<td>3,620,571</td>
<td>35,455</td>
<td>31%</td>
<td>Opportunity cost effect</td>
</tr>
</tbody>
</table>

Note: This table breaks down the reduction of purchases that can benefit from the Schumer plan in subsequent steps based on trade-in behavior, vehicle eligibility, incentives, and additionality.
Table 6: Scrappage additionality calculations for one year

<table>
<thead>
<tr>
<th></th>
<th>Schumer plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total vehicles scrapped under program (one year)</td>
<td>92,002</td>
</tr>
<tr>
<td>Eligible and incentivized non-additional scrappage percentage</td>
<td>9.55%</td>
</tr>
<tr>
<td>Total non-additional scrapped vehicles</td>
<td>8,786</td>
</tr>
<tr>
<td>Total additional scrapped vehicles</td>
<td>83,216</td>
</tr>
<tr>
<td>Ratio of additional scrapped vehicles per additional clean car</td>
<td>4.21</td>
</tr>
<tr>
<td>Average change in used vehicle equilibrium prices post scrappage</td>
<td>1.0%</td>
</tr>
<tr>
<td>Average price-related change in equilibrium used vehicle scrappage</td>
<td>-0.4%</td>
</tr>
<tr>
<td>Scrappage offset due to used car market equilibrium effects</td>
<td>11,244</td>
</tr>
<tr>
<td>Additional scrappage net of equilibrium effects</td>
<td>71,972</td>
</tr>
</tbody>
</table>

Notes: This table provides additionality calculations for vehicle scrappage based on vehicle disposal methods provided in Table 4. The table also provides a measure of the equilibrium effects of the Schumer plan increase in projected used vehicle scrappage. An increase in scrapped vehicles will reduce the supply of used vehicles available for sale in the used vehicle market, which will increase used vehicle prices and thus delay scrappage of some vehicles. The equilibrium effects in this table estimate the “scrappage rebound” that may be experienced due to the reduction in used vehicle supply created by the Schumer plan. There are 137 used vehicle variants in the equilibrium model from Ankney et al. (2022). The vehicles are defined based on age, vehicle type (e.g., sedan, SUV), and fuel type. Of these 137, 85 of them appear in our population of additional scrapped vehicles from the Schumer analysis. This covers most used vehicle variants in the model that would be eligible for the Schumer plan as trade-ins (i.e., at least 8 years old and gasoline-powered). We use these 85 vehicle variants only—not the entire used vehicle market—to calculate the equilibrium effects of scrappage due to the Schumer plan.